1,049,292

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,049,292

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Application made in Japan (No. 11558) on Feb. 25, 1963.
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Int. Cl.:—B 01 d

COMPLETE SPECIFICATION

Improvements relating to Vacuum Cleaners

We, TOKYO DENKI KABUSHIKI KAISHA, a joint-stock company of Japan, of 1 of 665, 1-Chome, Nakameguro, Meguro-ku, Tokyo 2, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to vacuum cleaners.

The dust filtering and collecting means used in a conventional vacuum cleaner has generally been formed from a gas-permeable and relatively thin fabric or paper, either singly or in combination. During use of such a dust collecting bag (hereinafter referred to as a dust bag), the dust sucked into the cleaner is arrested on the surface of the fabric or paper. Consequently, a conventional cleaner has the disadvantages that the minute pores of the dust bag soon become clogged. For this reason, long before the space within the dust bag is fully occupied by coarse dust particles, the suction air flow rate of the vacuum cleaner is rapidly reduced, whereby the dust collecting efficiency is also reduced.

Furthermore, the fine dust particles introduced into a conventional dust bag cannot be arrested as desired, and the quantity of fine dust transmitted through the pores of the dust bag is of a substantial magnitude which cannot be neglected.

It is another disadvantage of the known dust bags that the disposal of the dust is troublesome or is uneconomical, and the dust tends to scatter during removal and soil the surrounding objects, and is unhygienic.

Disposable dust bags such as those made of paper have the disadvantage of high price. Dust bags which can be washed with water have been proposed, but these are inconvenient because they cannot be used until they have been dried after washing.

It is an object of the present invention to provide a vacuum cleaner in which the above described disadvantages are avoided.

According to the present invention, there is provided a vacuum cleaner comprising a housing, a dust receptacle which is open at one end and is arranged in the housing, and a suction driving means, at least one part of the said dust receptacle being of an air-permeable, synthetic resin foam material adapted to entrap and collect fine dust particles during operation and capable of being reconditioned by washing to remove the fine dust particles collected therein.

Because of the unique character of the dust arresting and collecting means according to the present invention, the fine dust particles are not intercepted on the outer surface of the synthetic resin foam material but are entrapped in the interior in the direction of the thickness thereof. Accordingly, efficient dust filtration and collection is obtained without clogging of the pores through which the carrier air passes. Furthermore, after easy disposal of the collected dust from the said means by washing, the means can be used again even before it is dry.

In the accompanying drawings, in which like parts are designated by like reference characters:

Fig. 1 is an elevation in longitudinal vertical section showing the essential construction of one embodiment of the invention;

Fig. 2 is a graphical representation show-

ing curves indicating a comparison of the performance of a conventional vacuum cleaner and that of the vacuum cleaner of the present invention;

Fig. 3 is a perspective view, with a part cut away, showing an example of a dust receptacle for use in the embodiment of Fig. 1;

Fig. 4 is an elevation in longitudinal vertical section of another example of a dust receptacle;

Fig. 5 is a fragmentary view showing one part of a modification of the dust receptacle shown in Fig. 4;

Fig. 6 is a sectional view taken along the line VI—VI shown in Fig. 5;

Fig. 7 is a fragmentary view showing one part of another modification of the dust receptacle shown in Fig. 4;

Fig. 8 is a sectional view taken along the line VIII—VIII shown in Fig. 7;

Fig. 9 is a partial elevation in longitudinal vertical section showing the dust receptacle and intake section of another embodiment of the vacuum cleaner of the invention;

Fig. 10 is a perspective view showing an essential part used in the vacuum cleaner shown in Fig. 9;

Fig. 11 is an elevation in longitudinal vertical section showing the essential construction of another embodiment of the vacuum cleaner to the invention;

Fig. 12 is an elevation partly in vertical section showing the essential construction of an embodiment of the invention, which is a vacuum cleaner of the tank type;

Fig. 13 is a graphical representation indicating relationships between air flow rate and degree of vacuum;

Figs. 14 and 15 are fragmentary view showing respectively different modifications of the embodiment of Fig. 11;

Fig. 16 is an elevation in longitudinal vertical section showing a modification of the embodiments of Figs. 4 and 9;

Fig. 17 is an elevation in longitudinal vertical section of a modification of the embodiment of Fig. 4;

Fig. 18 is a fragmental sectional view of a further modification of the embodiment of Fig. 11; and

Fig. 19 is an elevation in longitudinal vertical section showing other embodiment of the present invention.

Referring to Fig. 1, the vacuum cleaner embodying the invention has a cleaner housing 1 containing a fan 3 driven by an electric motor 2, a front cover 5 having an intake port 4 at one end of the housing 1 and a discharge port 6 at the other end. A dust receptacle 7 is disposed in the space formed between the fan 3 and front cover 5. The dust receptacle 7, is made of an air-permeable, thick, synthetic resin foam material formed into a cup-shaped structure.

Example of materials suitable for the dust receptacle 7 are those composed principally of synthetic resins such as urethane resins and styrene resins. The dust receptacle 7 may, if so desired, be used in conjunction with a second dust bag (not shown) made of fabric or paper of known kind.

The vacuum cleaner shown in Fig. 1 is further provided with a handle 8, casters 9, a latch 10 for locking the front cover 5 in closed position, and a packing 11 fixed at the entrance to the dust receptacle 7. The dust receptacle 7 is held in correct position within the housing 1 by clamping its packing 11 between the housing 1 and the front cover 5.

The vacuum cleaner operates in the following manner. Operation of the fan 3 causes air and dust to be sucked from a suction pipe (not shown), through the intake port 4, and into the dust receptacle 7. Coarse dust particles are first arrested on the interior surface of the cup-shaped dust receptacle and are trapped in the space in the interior of the receptacle 7. Fine dust particles infiltrate further from the surface into the inner parts of the porous synthetic resin foam material of the receptacle and, in regions near the surface or deeper regions of the resin material, adhere to the interior surfaces of the foam voids or bubbles.

Since the fine particles are arrested in a three-dimensional manner, that is, in the thickness direction, in the thick, synthetic resin foam material constituting the dust receptacle 7, the probability of the pores, that is, the air bubbles through which the air flows, becoming clogged by the mechanism of arresting the fine particles is extremely low. The reason for this is that, because of the presence of countless air bubbles within the resin material, an extremely large adhesion surface for fine dust particles is formed three-dimensionally by the air bubbles and the very thin synthetic resin films connecting these bubbles, so that the fine dust arresting action is accomplished in a highly effective manner

Thus, the air which has passed through the dust receptacle 7 and has become dust-free then passes through the fan 3 and is forcibly discharged through the discharge port 6.

Accordingly, according to the construction of the embodiment of Fig. 1, since a large quantity of fine dust particles can be effectively entrapped without any large reduction due to clogging in the air flow rate, it is possible to maintain the dust collecting performance in an excellent state until the hollow space in the interior of the cup-shaped dust receptacle 7 becomes substantially full of coarse dust particles. It will be obvious that this means that the vacuum cleaner can be operated over a long period between dust disposal procedures.

For disposal of the dust in the dust recep-

tacle 7 after much dust has been collected, the dust receptacle 7 is removed from the housing 1, and its entrance opening is directed downwardly so that the coarse dust particles can be shaken out. The dust receptacle is then immersed in a washing liquid and squeezed. In this manner it is possible to cause the fine dust particles entrapped within the synthetic resin foam material to flow out readily and rapidly into the washing liquid. It will be appreciated that since this procedure involves discharging fine dust by washing, there is no possibility of the fine dust being scattered to soil the surrounding objects, and that this procedure is, therefore, hygenic.

The dust receptacle washed in the above described manner can be fitted in the housing 1 without drying and re-used.

The curves presented in Fig. 2 for the purpose of comparison between the performances of a representative vacuum cleaner of conventional type and of a vacuum cleaner according to the present invention are based on tests conducted with a powder which to stimulates dust. Each curve indicates progressive variation (lowering) of air flow rate (abscissa) with the quantity of powder (ordinate) sucked into the vacuum cleaner, curve (A) being that for the conventional cleaner, and curve (B) being that for the cleaner of this invention. For the purpose of this comparison, the tests were carried out with exactly the same apparatus other than the dust receptacles and under the same conditions.

It will be observed from Fig. 2 that, in the case of the conventional cleaner (curve (A)), its air flow rate tends to decrease rapidly when only a small quantity of powder has been sucked in, so that it is clear that its dust-collecting capacity is greatly limited. In contrast, as can be observed from curve (B), in the case of the cleaner of this invention, there is almost no change in the air flow rate with respect to its initial value even after a substantial quantity of powder has been sucked in.

In an embodiment of the dust receptacle 7 according to the invention, the dust receptacle 7, as shown in Fig. 3 consists of a cylindrical part 7*a* formed by circularly bending a synthetic resin foam material in plate form and bonding the butt seam and an end plate part 7*b* of disc shape made of the same material as the cylindrical part 7*a* and bonded to one end surface of the cylindrical part 7*a*. This construction is advantageous in that the dust receptacle 7 can be fabricated in a simple and easy manner at low cost from a plate stock material.

In another dust receptacle 7 according to the invention as shown in Fig. 4, a corrugated surface 12 is formed on the interior wall of the cup-shaped dust receptacle. By providing such a corrugated form, it is possible to reduce the detrimental effect due to adhesion in a thin film state on the interior wall of the receptacle of waste substances of fibrous, readily-entangling nature such as cotton lint or fluff whereby the infiltration of the fine dust particles into the synthetic resin foam material is obstructed. Moreover, such a construction affords an interior wall area which is several times that in the case of an even circular wall. Still another desirable feature of this construction is that the fine particles are thereby caused to impinge on the synthetic resin material at various angles, so that the dust collecting efficiency is substantially higher than that in the case illustrated in Fig. 1.

The configuration of the corrugated surface 12 need not be limited to the helical arrangement illustrated in Fig. 4, but may be arranged in a zig-zag manner with waves 12*a* of relatively sharp ridges and valley bottoms as shown in Figs. 5 and 6, or the undulations may take the form of protruding mounds 12*b* as shown in Figs. 7 and 8.

In still another embodiment of the invention as shown in Figs. 9 and 10, the dust receptacle 7 has within its hollow interior, against its closed end, an auxiliary filter piece 13 consisting of a strip of the same material as the receptacle 7, the strip being wound into a spiral as shown most clearly in Fig. 10. By this construction, the dust collecting effectiveness of the dust receptacle can be increased still more relative to that of the embodiments of the invention described hereinbefore. That is to say, the above described construction prevents any transmission of fine dust particles through the closed end of the dust receptacle, particularly in cases where this closed end part is of the same thickness as or is thinner than the cylindrical part of the receptacle. Furthermore, by using a strip of material with corrugations on one or both surfaces thereof for the wound strip 13 as shown in Figs. 9 and 10, suitable spaces 14 can be formed between the wound layers, whereby the effective surface area of the auxiliary filter piece 13 is increased and functions to increase the dust-collecting effectiveness.

In still another embodiment of the invention as shown in Fig. 11, the dust receptacle consists of an assembly of three different receptacles in concentric and successively encompassing arrangement. The innermost or first-stage receptacle 17 has the function of arresting and collecting only coarse waste matter such as cotton lint, paper waste, metal chips, and broken glass chips and may be of a character fully permitting passage of fine dust. Principal examples of materials suitable for fabrication of this first-stage receptacle 17 are coarse-weave fabrics of natural or man-made fibres, perforated or porous materials of synthetic resins or metal, and metal wire mesh

material with relatively large mesh. The intermediate or second-stage receptacle 18, which encompasses the first-stage receptacle 17, has the function of arresting and collecting fine dust particles and is fabricated from an air-permeable, synthetic resin foam material as used in the embodiments of the invention described hereinbefore. The outmost or third-stage receptacle 19, which encompasses the second-stage receptacle 18, has the function of thoroughly arresting and collecting any fine dust which may pass through the second-stage receptacle and is made of a fine-mesh material, examples of which are fabrics such as velveteen of known kind.

During the operation of the vacuum cleaner shown in Fig. 11, the intake air containing waste material and dust first enters the hollow interior of the first-stage receptacle 17, and coarse particles are arrested by the coarse mesh of the receptacle 17, while fine dust particles pass therethrough and infiltrate into the second-stage receptacle 18 to be entrapped in the manner described hereinbefore. Any dust particles which may pass through the second-stage receptacle 18 are arrested by the third-stage receptacle 19.

In contrast to conventional dust bags which tend to become clogged in a short time, as mentioned hereinbefore, the three-stage receptacle of the vacuum cleaner shown in Fig. 11 has a remarkable dust filtering and collecting capacity. Since the third-stage receptacle envelops the second-stage receptacle 18, the outer surface of the synthetic resin material of the second-stage receptacle 18 is caused by the passage of air during operation to rub against the inner surface of the third stage receptacle 19. Consequently, the fine dust particles arrested on the inner surface of the third-stage receptacle 19 are prevented from tenaciously adhering to the surface, being rendered into readily flowing particles. The fine dust particles arrested and collected in the third-stage receptacle 19 can therefore, also be discharged and disposed of in an easy manner.

The principles and teaching of the present invention can also be applied to vacuum cleaners of the so-called tank type (also known as the pot type) as illustrated by further embodiments of the invention shown in Figs. 12 and 14.

Referring to Fig. 12, the outer housing structure of the vacuum cleaner shown consists of the main body 21 containing a fan 23 driven by a motor 22, both mounted on a partition plate 31, and a pot-shaped dust collector 24 on which the main body 21 is detachably secured, with a packing 33 interposed therebetween, by a clamp latch 36. Between this dust collector 24 and the partition plate 31, are clamped filter elements 27, 28, and 29 disposed in coaxially stacked arrangement in the sequence named from bottom to top and constituting, respectively, the first, second, and third filtration stages. In fabrication material and function, these filter elements 27, 28 and 29 are similar to the dust receptacles 17, 18 and 19, respectively, in the example described in conjunction with Fig. 11 except for their convex configuration on their upstream side.

The combination of filter elements 27, 28 and 29 is so supported that a space for collection of coarse dust and waste is formed between this combination and the bottom of the dust collector 24, which is provided with an intake port 25, and this combination is prevented from being forced against the fan 23 by a support frame 30.

The vacuum cleaner shown in Fig. 12 is further provided with an air discharge port 26, a shock absorbing rim 32 made of an elastic material provided on the bottom flange of the main body 21 and serving as the contact surface to contact the packing 33, a handle 34, and casters 24*a*.

In the operation of the vacuum cleaner of the above described construction, the larger particles of dust and waste drawn in together with air through the intake port 25 are arrested by the collector 24 and the first-stage filter element 27 and collect it in the bottom of the dust collector 24. The fine dust particles, which tend to cause clogging in conventional vacuum cleaners, then pass through the first-stage filter element 27 and are entrapped by the second-stage and third-stage filter elements 28 and 29 similarly as in the case described with reference to Fig. 11.

It has been found by microscopic examination and measurement that almost all of the small quantity of dust particles adhering to the surface of the third-stage filter element 29 have grain sizes of the order of 50 microns, there being almost none of grain sizes of 10 microns, or less, and no evidence of clogging of the filter material was observed. It has also been found that these dust particles can be readily disposed of from the filter element 29.

As a result of tests with a powdered simulating dust, similar to those described hereinbefore, the curves of degree of vacuum (abscissa) versus air flow rate (ordinate) shown in Fig. 13 were obtained. Curves E, D and C represent performances respectively of the case in which the intake air contained no dust whatsoever, the case in which a conventional dust bag was used, and the vacuum cleaner was operated to draw in a certain quantity of the powder, and the case in which the filter elements 27, 28 and 29 according to the present invention were used, and the same quantity of powder was drawn in. From these curves, it will be observed that, whereas the performance drops in the case of the conventional dust bag, there is almost no variation in performance in the case of the filter elements of the present invention.

In the embodiment of Fig. 14 which is a modification of the embodiment of Fig. 11, the innermost first-stage receptacle 17 of large mesh and the second-stage receptacle 18 fabricated from an air-permeable, synthetic resin foam material are bonded as a single body by gluing, or welding. Of course, the third-stage receptacle 19 is supported so as to be detachable from the second-stage receptacle 18. According to the embodiment of Fig. 15 removal of collected dust can be easily accomplished by subjecting the assembly by the first-stage and second-stage receptacles to water-washing and by striking the third-stage receptacle 19, whereby handling is greatly facilitated. In this embodiment, numerals 11 and 48 indicate respectively a packing and a hinge for openably attaching the suction cover 5 having an intake port 4 to the housing.

In the embodiment of Fig. 15 which is another modification of the embodiment of Fig. 11, the first-stage, second-stage and third-stage receptacles are bonded as a single body by gluing, or welding. This embodiment includes a filtering member of one body, so that its handling is extremely easy.

The constructional ideas of the above-mentioned embodiments of Figs. 14 and 15 can be applied to the cases in which the filtering member is of a dish-shaped type or plate-shaped type.

The embodiment of Fig. 16 relates to the case, in which members similar to those of the embodiment of Fig. 1 are designated by the same reference characters, and the thick dust receptacle 7 consists of cup-shaped inner and outer members *7b* and *7c*, each being fabricated from an air-permeable, synthetic resin foam material, and at least the outer member being provided with a corrugated surface 12 so that a continuous air gap or discontinuous air gaps *7d* are formed between the facing surfaces of members *7b* and *7c*. The air gap or gaps is or are substantially larger than the bubbles or pores formed in the bodies of the members *7b* and *7c*.

The embodiment of Fig. 17 is a modification of the embodiment of Fig. 17 and relates to the case in which the filtering member 7 consists of three layers *7e*, *7f* and *7g* of synthetic resin foam material the intermediate layer *7g* being made to be relatively thin, whereby the air gaps *7h* and *7i* are formed on both sides of the intermediate layer *7g*. According to the embodiment of Fig. 18, since the velocity of the air which has passed through the body of the filtering member is decreased at the said air gaps, arresting and collection of fine dust are further improved.

The embodiment of Fig. 18 is a further modification of the embodiment of Fig. 11 and relates to the case in which the first-stage receptacle 17 is provided at its opening portion with a flange portion 49, the third-stage receptacle 19 is provided with a packing 11 overlapping the flange portion 49, and the second stage receptacle 18 fabricated from an air permeable, synthetic foam material is disposed between the said first-stage and third-stage receptacles. The above-mentioned flange portion 49 and packing 11 are supported between, the main housing 1 and the front cover 5.

Fig. 20 shows another embodiment of the present invention in which the filtering member consists of a side wall 50 and a thick base member 51 supported by the said side wall and fabricated from an air-permeable, synthetic resin foam material. Substantial airtightness of the side wall means that the airtightness of the side wall is greater than that of the member 51. For instance, the side wall may be made of a material such as vinyl film.

WHAT WE CLAIM IS:—

1. A vacuum cleaner comprising a housing, a dust receptacle which is open at one end and is arranged in the housing, and a suction driving means, at least one part of the said dust receptacle being of an air-permeable, synthetic resin foam material adapted to entrap and collect fine dust particles during operation and capable of being reconditioned by washing to remove the fine dust particles collected therein.

2. A vacuum cleaner according to claim 1, in which the receptacle is a removable cylinder having a base wall.

3. A vacuum cleaner according to claim 2, in which the receptacle is formed by bending a sheet of the synthetic resin foam material into a cylindrical form, edges of the sheet being butt-joined and bonded together, and an end plate part of the same material as the cylindrical part being bonded to one end of the cylindrical part.

4. A vacuum cleaner according to any preceding claim, in which the receptacle is a second-stage dust filter element which envelops a first-stage dust filter-element formed of a relatively large mesh material to arrest and collect coarse dust particles, a third-stage dust filter element of relatively fine mesh material enveloping the second-stage element.

5. A vacuum cleaner according to claim 1, in which the receptacle is a second-stage dust filter element and is combined with a first-stage dust filter element which is of relatively large mesh material for arresting coarse dust particles which envelops the second-stage filter element and a third-stage dust filter element of relatively fine mesh which is enveloped by the second-stage filter element.

8. A vacuum cleaner according to either of claims 4 or 6, in which the second-stage element and the first-stage element are bonded as a single body.

9. A vacuum cleaner according to either of claims 4 or 6, in which the first-stage, second-

stage and third-stage elements are bonded to form a single body.

10. A vacuum cleaner according to claim 1, in which the dust receptacle consists of inner and outer members, each of an air-permeable, synthetic resin foam material, at least the inner member being provided, at its surface confronting the other member, with a corrugated or ribbed surface forming air gaps between the members.

11. A vacuum cleaner according to claim 1, in which the dust receptacle has three overlapping layers, each of air-permeable, synthetic resin foam material, the intermediate layer being thin, and the outer and inner layers being provided with, on their surfaces confronting the said intermediate layer, corrugations or protrusions so that air gaps are formed on both sides of the intermediate layer.

12. A vacuum cleaner according to claim 4 as dependent on claim 1, in which the first-stage element is provided at its open end with a flange portion and the third-stage element is provided with a packing overlapping the flange portion, the said flange portion and packing being clamped with the housing.

13. A vacuum cleaner substantially as described with reference to the accompanying drawings.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

FIG. 1

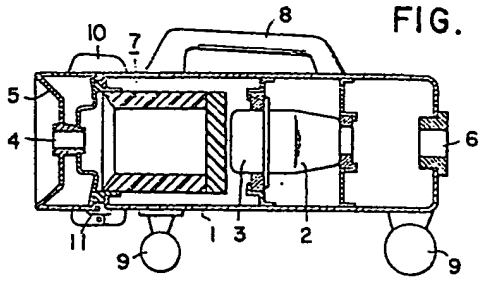


FIG. 2

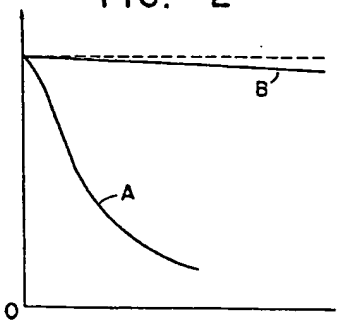


FIG. 3

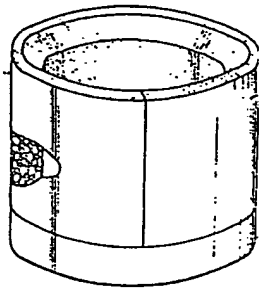


FIG. 6

FIG. 5

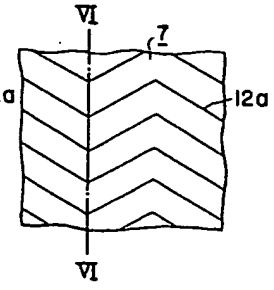
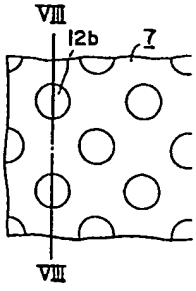


FIG. 8

FIG. 7



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Sheets 1 & 2

FIG. 1

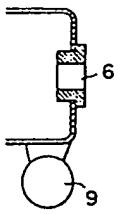


FIG. 4

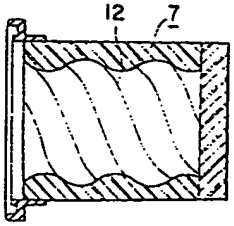


FIG. 9

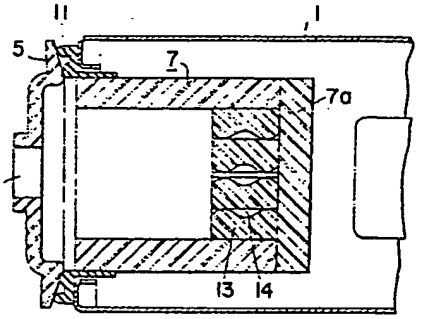


FIG. 3

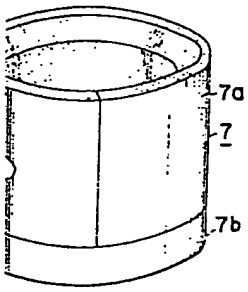


FIG. 10

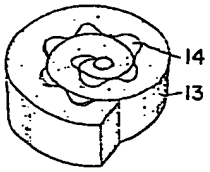


FIG. 11

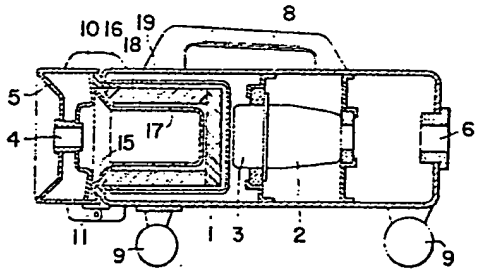


FIG. 7

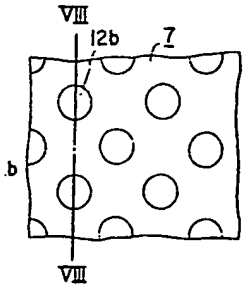


FIG. 13

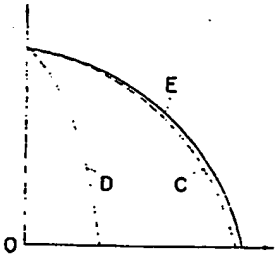
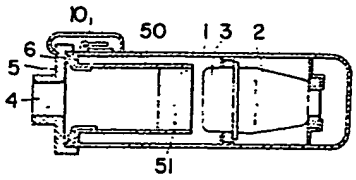


FIG. 19



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Sheets 1 & 2

FIG. 1

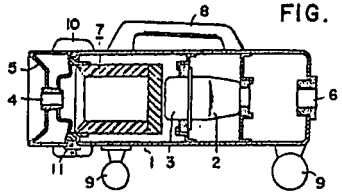


FIG. 2

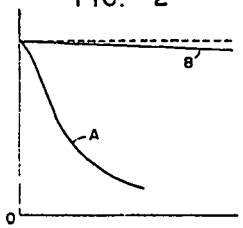


FIG. 3

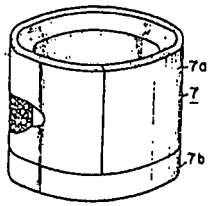


FIG. 4

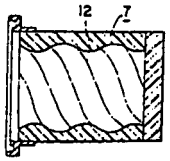


FIG. 9

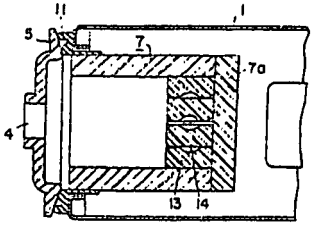


FIG. 10

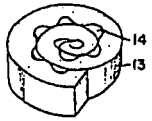


FIG. 11

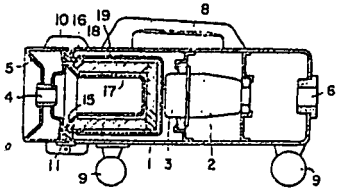


FIG. 6

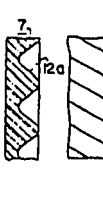


FIG. 5

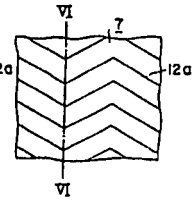


FIG. 8

FIG. 7

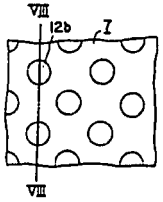


FIG. 13

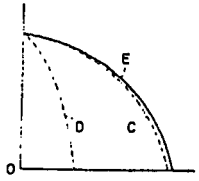


FIG. 19

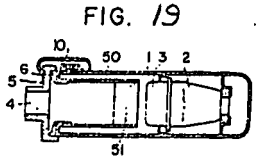
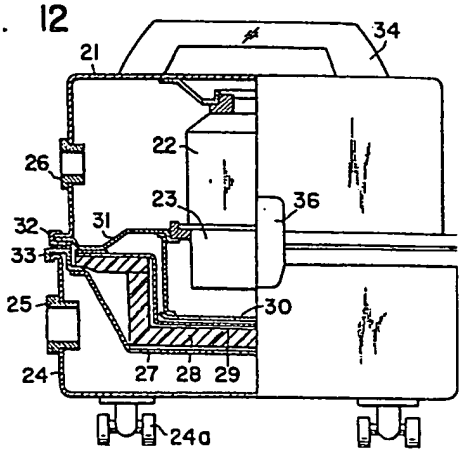


FIG. 12



1049292 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 3 & 4

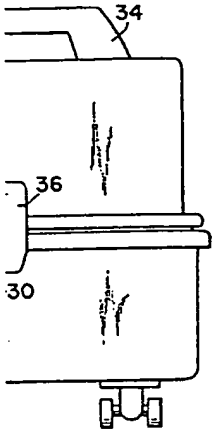


FIG. 14

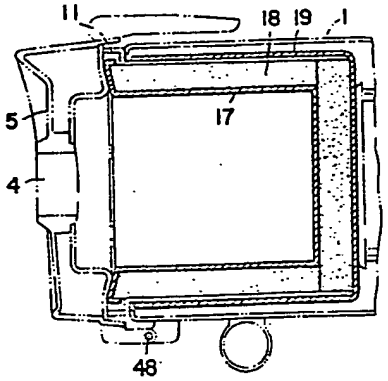


FIG. 15

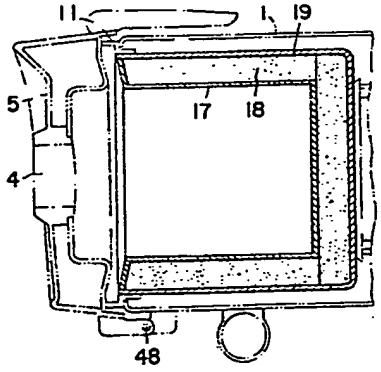


FIG. 16

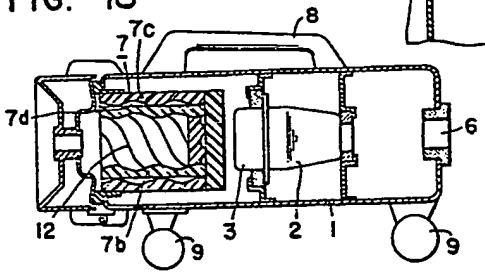


FIG. 17

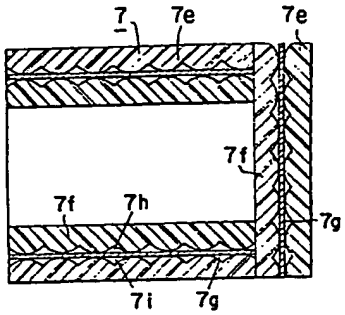
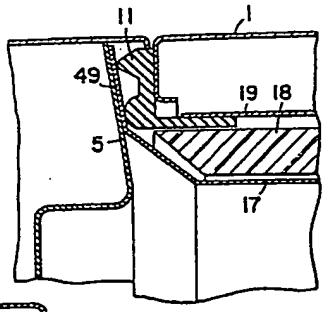


FIG. 18



1049292 COMPLETE SPECIFICATION
4 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 3 & 4

FIG. 12

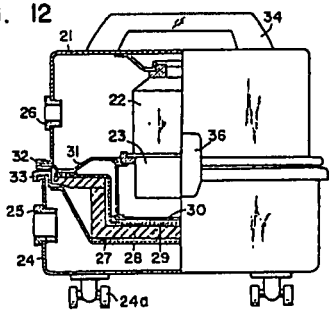


FIG. 14

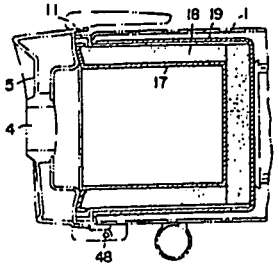


FIG. 17

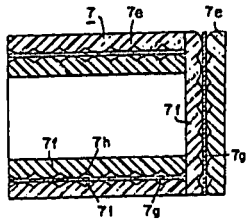


FIG. 15

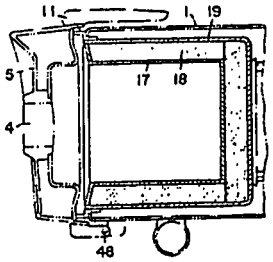


FIG. 18

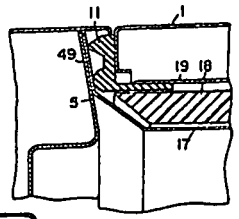


FIG. 16